REINFORCED CONCRETE LIGHT MANUFACTURING BUILDING

BY

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1913

DESIGNS and PLANS

for

A Four Story Reinforced Concrete Light Manufacturing Building

100'-0" x 150'-0"

A Thesis

presented by

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to the

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of

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Design of four story and basement reinforced concrete building of Class One of Chicago Building Ordinance.

DATA:

Proposed building to be constructed of reinforced concrete skeleton and vitified brick curtain wall.

Span of Floor Beam	20'-0"
" " " Girder	I6'-8"
" " " Slab	8'-4"
Live Load on Floor	I00#/□'
" " " Roof	25#/□'
Weight of Roofing Composition	7#/□'
" " Concrete I - 2 - 4	I50# cu.ft.

STRESSES:

Unit Shearing Stress plain concrete	40#/□"
" Tensile " steel "	I5000#/□"
" Shearing " " "	I2000#/□"
" Complete " reinforced concrete	700#/□"
Allowable Compression Stress plain concrete	400#/□"
" Bond "	70#/□"
" Pressure on soil	5000#/□"

ROOF SLAB.

End Slab.

Live Load	25# sq.ft.
Roofing Composition	7 " "
3" Slab	37.5 " "
Total Load	69.5# sq.ft.

$$M = \frac{W L^2}{I0} = \frac{69.5 \times \overline{8.33}^2 \times I2}{I0} = 5800"\#$$

$$d^2 = \frac{M \times 6}{f_c \times b} = \frac{5800 \times 6}{600 \times I2} = 4.83 \qquad d = 2.2" \qquad \text{Use 3" slab.}$$

$$A = \frac{M}{f_s\, jd} \quad - \quad \text{Effective depth} = 3 - 3/4 = 2\text{-}I/4"$$

$$A = \frac{5800}{I5000 \times .875 \times 2.25} = .I97^{\square}"$$

Use 3/8" round rods, spacing 6", area $2.2^{\square}"$.

$$V = \frac{8.33 \times 69.5}{2} = 290\# \qquad V' = \frac{290}{3 \times I2} = 8.05\#^{\square}" \qquad 40\# \text{ allowable}$$

$$U = \frac{V}{\Sigma o\, jd} = \frac{290}{(I2 \times I.I8) \times .875 \times 2.25} = 62.5\#^{\square}" \qquad 70\# \text{ allowable}$$

Intermediate Slab.

Same thickness as end slab.

$$M = \frac{W L^2}{I2} = \frac{69.5 \times \overline{8.33}^2 \times I2}{I2} = 4830"\#$$

$$A = \frac{4830}{I5000 \times .875 \times 2.25} = .I7\#^{\square}"$$

Use 3/8" round rods, spacing 6" to take care of bond stress.

ROOF BEAM.

End Beam Span 20' 0"

$$M = \frac{W\ b\ L^2}{10} = \frac{69.5 \times 8.33 \times \overline{20}^2 \times 12}{10} = 278000"\#$$

B.M. due to weight of beam $= \frac{12.5 \times 6}{144} \times \frac{150 \times 20 \times 12}{8} = 47000"\#$

Total M = 278000 + 47000 = 325000"#

$$V = \frac{20 \times 8.33 \times 69.5}{2} = 5800\#$$

$$U = 100\#^{a}" \qquad \frac{5800}{100} = 58$$

$$db = 58 \qquad b = \frac{58}{14} = 4.2" \qquad \text{Use } 6"$$

$$\frac{t}{d} = \frac{3}{14} = .22 \qquad \text{From Plate IX} \qquad \text{T. \& M.}$$

$$\frac{M}{bd} = 85 \qquad j = .905$$

$$b = \frac{M}{85 \times 14} = \frac{325000}{85 \times 196} = 19.5"$$

$$j = .905 \qquad jd = .905 \times 14 = 12.7"$$

$$A = \frac{M}{f_s\ jd} = \frac{325000}{15000 \times 12.7} = 1.71^{a}"$$

Use four 3/4" round rods, area 1.77 "

$$u = \frac{V}{\Sigma o \times jd} = \frac{5800}{(2.36 \times 4) \times 12.7} = 48.3\#^{o}" \qquad \text{Safe in bond stress}$$

$$v = \frac{5800}{6 \times 14} = 69\#^{o}" \qquad \text{Concrete takes } 40\#$$

69 - 40 = 29#°" to be taken by steel.

$$S = \frac{d}{4} = \frac{14}{4} = 3\text{-}1/2" \text{ spacing } 4".$$

$$P = V\ b\ s$$

$$P = 29 \times 6 \times 4 = 700\#$$

$A = \frac{700}{I2000} = .059^{\square"}$

Use I/4" round U bars, spacing 4", starting at point 5'-6" to support. Turn up one horizontal bar 2' from center and one 6'.

Roof Girder Span I6'-8"

$M = \frac{I3I40 \times \overline{I6.7}^{2} \times I2}{I0} = 263500"\#$

$M = \frac{I2-I/2 \times 6 \times I50 \times \overline{I6.7}^{2} \times I2}{I44 \times 8} = 32700"\#$

Total $M = 263500 + 32700 = 296200"\#$

$V = \frac{I3I40}{2} + \frac{I2-I/2 \times 6 \times I50 \times I6.7}{I44 \times 2} = 7I72\#$

$b\,d = \frac{7I72}{I00} = 72 \qquad d = I4" \qquad b = \frac{72}{I4} = 5.34" \qquad$ Use 6"

$\frac{t}{d} = \frac{3}{I4} = .22 \qquad \frac{M}{bd} = 85 \qquad j = .905$

$b = \frac{296000}{85 \times I96} = I7.8"$

$jd = .905 \times I4 = I2.7"$

$A = \frac{296000}{I5000 \times I2.7} = I.55^{\square"}$

Use three 7/8" round rods, area $I.803.^{\square"}$

$u = \frac{7I72}{2.75 \times 3 \times I2.7} = 68.3\#^{\square"}$

$v = \frac{7I72}{6 \times I4} = 85.5\#$

$v = 85.5\# - 40 = 45.5\#$ shear to be carried by steel.

$P = v\,b\,s = 45.5 \times 6 \times 4\text{-}I/2 = I230\#^{\square"}$

$A = \frac{I230}{I2000} = .I025^{\square"}$

Use I/4" round U bars, spacing 4'-6" from center.

Wall Roof Girder. Span I6'-8".

$$M = \frac{5800 \times \overline{I6.7}^2 \times I2}{5} = 233000"\#$$

$$M \text{ due to weight of beam} = \frac{I0 \times I8 \times I50 \times \overline{I6.7}^2 \times I2}{I44 \times 8} = 78500"\#$$

Total M = 233000 + 78500 = 3II500"#

$$d = \frac{3II500}{I0 \times 97.5} = 320 \qquad d = I7.9" \qquad \text{Use } I8"$$

$$A = \frac{M}{f_s jd} = \frac{3II500}{I5000 \times .875 \times I8} = I.32"$$

Use three 3/4" round rods, area I.33^{a}".

$$V = \frac{5800}{2} = \frac{I0 \times I8 \times I50 \times I6.7}{I44 \times 2} = 4465\#$$

$$u = \frac{4465}{I0 \times I8} = 24.8\#^{a}"$$

$$u = \frac{4465}{3 \times 2.36 \times .875 \times I8} = 40\#^{a}"$$

Wall Roof Girder. Span 20'.

$$M = \frac{69.5 \times 4.2 \times 400 \times I2}{I0} = I40000"\#$$

$$M = \frac{I0 \times I6 \times I50 \times 20 \times I2}{I44 \times 8} = I00000"\#$$

Total M = I40000 + I00000 = 240000"#

$$\frac{M}{bd^2} = 97.5 \qquad d^2 = \frac{240000}{I0 \times 97.5} = 246 \qquad d = I5.7"$$

Use I0" x I6" girder.

$$A = \frac{240000}{I5000 \times 7/8 \times I6} = I.I5^{a}"$$

Use two 7/8" round rods, area I.20^{a}".

$$v = \frac{69.5 \times 4 \times 20}{2} = 2920\#$$

$$v = \frac{2920}{10 \times 16} = 18.3\#^{a}"$$

$$u = \frac{2920}{2 \times 2.75 \times .875 \times 16} = 38\#^{a}"$$

FLOOR SLAB.

Exterior Slab. (8'-4" x 20'-0").

Live Load	100#^a"
4" Slab	50
Cement Finish	10
Total Load	160#^a"

$$M = \frac{W L^2}{10} \quad \frac{160 \times \overline{8.33}^{2} \times 12}{10} = 13350"\#$$

$$d^2 = \frac{6 \times 13350}{600 \times 12} = 11.13 \qquad d = 3.34" \qquad \text{Use 4" slab.}$$

$$A = \frac{M}{f_s \times .875 \times d} = \frac{13350}{15000 \times .875 \times 3.25} = .306^{a}"$$

Use 3/8" round rods, spacing 4".

$$V = \frac{8.33 \times 160}{2} = 667\#$$

$$v = \frac{667}{12 \times 4} = 13\#^{a}"$$

$$u = \frac{V}{\Sigma o \; jd} = \frac{667}{(3 \times 1.18) .875 \times 3.25} = 66.3\#^{a}"$$

Interior Slab.

Same thickness as exterior Slab.

$$M = \frac{W L^2}{12} = 1113 0"\#$$

$$A = \frac{1113 0}{15000 \times .875 \times .325} = .26^{a}"$$

Use 3/8" round rods, spacing 4-1/2".

$$U = \frac{V}{\Sigma o\ jd} = \frac{667}{3.15 \times .875 \times 3.25} = 74\#/"$$

Use 3/8" round rods, spacing 4" same as exterior slab to take care of bond stress.

FLOOR BEAM.

End Beam — Span 20'.

$$M = \frac{W\ b\ L^2}{10} = \frac{160 \times 8.33 \times \overline{20}^2 \times 12}{10} = 641000"\#$$

$$\text{B.M. due to weight of beam} = \frac{15-1/2 \times 9 \times 150 \times \overline{20}^2 \times 12}{144 \times 8} = 71800"\#$$

Total M = 641000 + 71800 = 712800"#

$$V = \frac{20 \times 8.33 \times 160}{2} = 13350\#$$

$$db = \frac{13350}{100} = 133.5$$

b = 8.33" Use 9"

$$\frac{t}{d} = \frac{4}{18} = .222 \qquad \frac{M}{bd^2} = 85 \qquad j = .90$$

$$b = \frac{71800}{85 \times 256} = .33"$$

jd = .90 x 18 = 16.2"

$$A = \frac{712800}{15000 \times 16.2} = 2.94/"$$

Use five 7/8" round rods, area 3.03/".

$$U = \frac{V}{\Sigma o \times jd} \quad \frac{13350}{(5 \times 2.75) \times 16.2} = 60\#/"$$

$$v = \frac{13350}{9 \times 18} = 82.5\#$$

82.5 - 40 = 42.5# carried by vertical rods.

P = v b s = 42.5 x 9 x 6 = 2300#

$$A = \frac{2300}{12000} = .192/"$$

Use 3/8" round U bars, area .22I$^{\square}$", spacing 4" for 2-I/2′ and 6" for 2-I/2′.

Floor Girder. Span I6′-8".

Load (floor reaction)	26700#
Weight of beam	2400
Total Load	29I00#

$$M = \frac{29I00 \times \overline{I6.7}^2 \times I2}{5} = II6800"\#$$

$$M = \frac{I5\text{-}I/2 \times 9 \times I50 \times \overline{I6.7}^2 \times I2}{I44 \times 8} = 60800"\#$$

Total M = II6800 + 60800 = I77600"#

$$V = \frac{29I00 + I45 \times I6.7}{2} = I5760\#$$

$$b\ d = \frac{I5760}{I00} = I57.6$$

Let d = I8" $\quad b = \frac{I57.6}{I8} = 8.75"$ Use 9"

$$\frac{t}{d} = \frac{4}{I8} = .222 \qquad \frac{M}{bd^2} = 85 \qquad j = .90 \qquad jd = .90 \times I8 = I6.2$$

$$b = \frac{I77600}{85 \times 324} = 44.6"$$

$$A = \frac{}{I5000 \times I6.2} = 5.06^{\square}"$$

Use nine 7/8" round rods, area 5.4$^{\square}$".

$$u = \frac{I5760}{2.75 \times 8 \times .90 \times I8} = 45\#^{\square}"$$

$$v = \frac{I5760}{I8 \times 9} = 97.3\#^{\square}"$$

97.3 - 40 = 57.3#$^{\square}$" to be carried by steel.

P = 57.3 x 9 x 4-I/2 = 2320#

$A = \frac{2320}{I2000} = .I97^{a}"$

Use 3/8" round U bars, spacing 4'-I0" from center of span.
Turn up 2 rods, 6' from center of span.

Wall Floor Girder. Span I6'-8".

$M = \frac{I4550 \times \overline{I6.7}^{2} \times I2}{5} = 583000"\#$

$M = \frac{300 \times \overline{I6.7}^{2} \times I2}{8} = I25000"\#$

Total M = 583000 + I25000 = 708000"#

$\frac{M}{bd^{2}} = 98 \qquad d^{2} = \frac{708000}{98 \times I2} \qquad d = 24"$

$A = \frac{708000}{I5000 \times .875 \times 24} = 2.II^{a}"$

Use three I" round rods.

$V = \frac{I4550 \times 300 \times I6.7}{2} = 9780\#$

$v = \frac{9780}{I2 \times 24} = 34\#^{a}"$

$u = \frac{9780}{3 \times 3.I4 \times .875 \times 24} = 44\#^{a}"$

Use I2" x 24" girder.

Wall Floor Girder. Span 20'.

Weight of Brick = $\frac{I3 \times I \times 3 \times I44}{I2} = 468\#$ per ft.

Floor Load = 667# per ft.

W = 468 + 667 = II35# per ft.

$M = \frac{W L^{2}}{I0} = \frac{II35 \times \overline{20}^{2} \times I2}{I0} = 544800"\#$

$M = \frac{I50 \times 2 \times 400 \times I2}{8} = I80000"\#$

Total M = 544800 + I80000 = 724800"#

$d^2 = \frac{724800}{I2 \times 98} = 6I5$ d = 24" Use I2" x 24" girder.

$A = \frac{724800}{I5000 \times .875 \times 24} = 2.2^{a}"$

Use three I" round rods, area $2.3^{a}"$.

$V = \frac{II35 \times 20}{2} = II350\#$

$v = \frac{II350}{I2 \times 24} = 39.5\#^{a}"$ $40\#^{a}"$ allowable.

$u = \frac{II350}{9.43 \times .875 \times 24} = 58\#^{a}"$

INTERIOR COLUMNS.

Fourth Floor.

Slab & Roofing	20 x I6.7 x 69.5	23200#
One Girder	$\frac{I2\text{-}I/2 \times 6 \times I50 \times I6.7}{I44}$	I305
Two Beams	$\frac{I2\text{-}I/2 \times 6 \times I50 \times I6.7}{I44}$	3I30
Assume Column	II" x II"	I390
Total Load		29025#

Let P = I.5%

P = f A (I - (n - I) p) = 400 x A (I - (I5 - I) .0I5)'

An II" x II" column allows I-I/2" for fireproofing.

Steel area = .0I5 x 60 = $.90^{a}"$.

Use four 9/I6" round rods, area $I.00^{a}"$.

Third Floor.

Roof Load	29025#
Fourth Floor Cement Finish	3340
" " 4" Slab	I6700

One Floor Girder	2430
Two " Beams	5820
Assume I6" x I6" Column	2940
85% Live Load Fourth Floor	28390
Total Load	88645#

Let P = 2%

$88645 = 400 \times A\ (I - (I5 - I)\ .02)$

$A = \frac{88645}{400 \times I.28} = I72^{\square}"$ b = I3"

A I6" x I6" column allows I-I/2" for fireproofing.

Steel area = $.02 \times I72 = 3.44^{\square}"$.

Use eight 3/4" round rods, area $3.53^{\square}"$.

Second Floor.

Roof Load	29025#
Fourth Floor Load	59620
Third Floor Dead Load	3I230
80% Live Load	26700
Assume 20" x 20" Column	4580
Total Load	I5II55#

Let P = 2.5%

$I5II55 = 400 \times A\ (I - (I5 - I)\ .025)$

$A = \frac{I5II55}{540} = 280^{\square}"$ b = I6.75"

A 20" x 20" column allows I-I/2" for fireproofing.

Steel area = $.025 \times 280 = 7.0^{\square}"$

Use nine I" round rods, area $7.07^{\square}"$.

First Floor.

Loading above Second Floor	I5II55#
Second Floor Loading	3I230
75% Live Load	25070
Assume 22-I/2" x 22-I/2" Column	5820
Total Load	2I3275#

Let P = 3%

$2I3275 = 400 \times A\ (I - (I5 - I)\ .03)$

$A = \frac{2I3275}{400 \times I.42} = 383^{a}"$ $\quad b = I9.5"$

A 22-I/2" x 22-I/2" column allows I-I/2" for fireproofing.

Steel area $= .03 \times 384 = II.52^{a}"$.

Use nine I-3/8" round rods, area $I3.3^{a}"$.

Basement.

Loading above First Floor	2I3275#
First Floor Dead Load	3I230
70% Live Load	23380
Assume Column 26" x 26"	7050
Total Load	274935#

Let P = 3%

$274935 = 400 \times A\ (I - (I5 - I)\ .03)$

$A = \frac{274935}{400 \times I.42} = 484^{a}"$ $\quad b = 22"$

A 25" x 25" column allows I-I/2" for fireproofing.

Steel area $= .03 \times 484 = I4.52^{a}"$.

Use ten I-3/8" round rods, area $I4.85^{a}"$.

Interior Column Footing.

Load = 274935# Column = 25" x 25"

5000# sq.ft. = allowable bearing pressure.

Load on Footing	274935#
Assume Weight of Footing	25000
Total Load	299935#

$\frac{299935}{5000}$ = 60 sq.ft. Use 7'-9" x 7'-9" footing.

$\frac{274935}{40 \times 4 \times 25}$ = 68.75" Dept of footing = 5'-9"

Shear reinforcing in footing short direction.

500 x 2.08 x 2.833 = 29500#

M = 29500 x I.4 = 4I300"#

$A = \frac{4I300 \times I2}{I5000 \times .875 \times 65} = .58"$

Use 5/8" round rods, spacing 6".

Shear reinforcing in footing diagonal direction.

5000 x 2.625 x 2.625 = 34500#

M = 34500 x 3.7I x I2 = I540000"#

$A = \frac{I540000}{I5000 \times .875 \times 65} = I.8^{a}"$

Use six 5/8" round ords, area $I.85^{a}$".

WALLS COLUMNS SpAN 20'

Fourth Floor.

Roof Slab and Load	II600#
One 20ft. Beam I0" x I6"	3330
One I6'-8" Beam I2-I/2" x 6"	I320
One half 20 ft Beam I2-I/2" x 6"	780

30" Paraput Wall I2"	6000
II" x II" Column	I290
Total Load	24320#

P = I.5%

$A = \frac{24320}{484} = 50.2^{a}"$ b = 7"

A II" x II" column is the minimum size allowable.

Steel area = .0I5 x 50.2 = $.75^{a}"$

Use four I/2" round rods, area $.80^{a}"$.

Tie rods every I2" with I/8" wire.

Third Floor.

4" Slab and Floor Finish	I0020#
One 20' Beam I2" x 24"	6000
One-half 20 Floor Beam I5-I/2" x 9"	I455
One I6'-8" Floor Girder I5-I/2" x 9"	2430
Brick Masonry	8000
One-half Panel of 85% Live Load	I4200
I4-I/2" x I4-I/2" Column	2200
Load from Fourth Floor Column	24320
Total Load	68625#

P = 2%

$A = \frac{68625}{5I2} = I34^{a}"$ b = II.5"

A I4-I/2" x I4-I/2" column allows I-I/2" for fireproofing.

Steel area = .02 x I4.5 = $2.90^{a}"$.

Use five 7/8" round rods, area $3.0^{a}"$.

Tie rods every I2" with I/8" wire.

Second Floor.

Load from Third Floor Column	68625#
Third Floor Dead Load	27905
One-half Panel of 80% Live Load	I3350
I7-I/2" x I7-I/2" Column	3200
Total Load	II3080#

P = 2.5%

$A = \frac{II3080}{540} = 209^{a}"$ b = I4.5 + 3 = I7.5"

A I7-I/2" x I7-I/2" column allows I-I/2" for fireproofing.

Steel area = .025 x 209 = $5.23^{a}"$.

Use nine 7/8" round rods, area $5.4^{a}"$.

Tie rods every I2" with I/8" wire.

First Floor.

Load from Second Floor Column	II3080#
Second Floor Dead Load	27905
One-half Panel 75% Live Load	I2535
20" x 20" Column	4I80
Total Load	I57700#

P = 3.0%

$A = \frac{I57700}{568} = 278^{a}"$ b = I6.7"

A 20" x 20" column allows I-I/2" for fireproofing.

Steel area = .03 x 278 = $8.34^{a}"$.

Use seven I-I/4" round rods, area $8.4^{a}"$.

Basement.

Load from Forst Floor Column	I57700#
First Floor Dead Load	27905
One-half Panel of 70% Live Load	II690
22" x 22" Column	4580
Total Load	20I875#

P = 3%

$A = \frac{20I875}{568} = 356''$" b = I8.9"

A 22" x 22" column allows I-I/2" for fireproofing.

Steel area = .03 x 356 = I0.68"

Use nine I-I/4" round rods, area II.0448".

Tie rods every I2" with I/8" wire.

Wall Column Footing.

Load on Footing	20I875#
Weight of Footing	20000
Total Load	22I875#

Area of base $= \frac{22I875}{5000} = 44.48''$' b = 6'-8"

$\frac{20I875}{40 \times 4 \times 22} = 57.4$" Make depth of footing 5'-0".

Shear reinforcing in short direction.

5000 x I.83 x 2.43 = 22300#

M = 22300 x I.25 = 27900 #

$A = \frac{27900 \times I2}{I5000 \times .875 \times 56} = .46''$"

Use three I/2" round rods.

Shear reinforcing in diagonal direction.

$5000 \times 2.43 \times 2.43 = 29500\#$

$M = 29500 \times 2.9I = 85800"\#$

$$A = \frac{85800 \times I2}{I5000 \times .875 \times 56} = I.4^{a}"$$

WALL COLUMNS SPAN I6'-8"

Fourth Floor.

Roof Slab and Load	II600#
One Wall Girder I0" x I8"	3I40
Two Roof Beams I2-I/2" x 6"	2640
30" Paraput Wall I2"	5000
II" x II" Column	I290
Total Load	23670#

$P = I.5\%$

$$A = \frac{23670}{484} = 49.0^{a}" \qquad b = 7"$$

An II" x II" column is the minimum size allowable.

Steel area $= .0I5 \times 49 = .735^{a}"$.

Use four I/2" round rods, area .80".

Tie rods every I2" with I/8" wire.

Third Floor.

Load from Fourth Floor Column	23670#
One Wall Girder I2" x 24"	5000
Two Floor Beams I5-I/2" x 9"	4860
One-half Slab and Floor Finish	I0020
Brick Masonry	6800
One-half Panel of 85% Live Load	I4200
I4-I/2" x I4-I/2" Column	2200
Total Load	66740#

P = 2%

$A = \frac{66740}{512} = 130^{\square}"$ b = 11.4"

A 14-1/2" x 14-1/2" column allows 1-1/2" for fireproofing.

Steel area = .02 x 130 = $2.6^{\square}"$.

Use six 3/4" round rods, area $2.6508^{\square}"$.

Tie rods every 12" with 1/8" wire.

Second Floor.

Load from Third Floor Column	66740#
Third Floor Dead Load	26680
One-half Panel of 80% Live Load	13350
17-1/2" x 17-1/2" Column	3200
Total Load	109970#

P = 2.5%

$A = \frac{109970}{540} = 204^{\square}"$ b = 14.3"

A 17-1/2" x 17-1/2" column allows 1-1/2" for fireproofing.

Steel area = .025 x 204 = $5.1^{\square}"$.

Use nine 7/8" round rods, area $5.4^{\square}"$.

Tie rods every 12" with 1/8" wire.

First Floor.

Load from Second Floor Column	109970#
Second Floor Dead Load	26680
One-half Panel of 75% Live Load	12535
20" x 20" Column	4180
Total Load	153365#

P = 3%

$A = \frac{153365}{568} = 270^{\square}"$ $\quad b = 16.4"$

A 20" x 20" column allows 1-1/2" for fireproofing.

Steel area $= .03 \times 270 = 8.1^{\square}"$.

Use seven 1-1/4" round rods, area $8.4^{\square}"$.

Tie rods every 12" with 1/8" wire.

Basement.

Load from First Floor Column	153365#
First Floor Dead Load	26680
One-half Panel of 70% Live Load	11690
22" x 22" Column	4580
Total Load	196315#

P = 3%

$A = \frac{196315}{568} = 346^{\square}"$ $\quad b = 18.6"$

A 22" x 22" column allows 1-1/2" for fireproofing.

Steel area $= .03 \times 346 = 10.38^{\square}"$.

Use nine 1-1/4" round rods, area $11.0^{\square}"$.

Tie rods every 12" with 1/8" wire.

RAFT FOOTING.

Load on Interior Column	274935#
" " Wall "	196315
Weight of Footing	80000
Pressure on Soil	501250#

$A = \frac{501250}{5000} = 100.25$

$\frac{6 + 3}{2} \times 22.5 = 101.5$

$\frac{47I250}{40 \times I66} = 72"$ depth of footing.

The raft footing is considered as a beam; the span being the distance between the two columns; the load the upward reaction of the earth. It is designed as an inverted T-beam.

$W = 5000 \times 4\text{-}I/2" = 22500\#$

$M = \frac{22500 \times \overline{20}^{2} \times I2}{I0} = I0,800,000"\#$

$V = \frac{22500 \times 20}{2} = 225000\#$

$\frac{22500}{I33} = I700$

$b\ d = I700 \qquad d = 68" \qquad b = \frac{I700}{68} = 25"$

$\frac{t}{d} = \frac{8}{68} = .II8 \qquad \frac{M}{bd^2} = 56 \qquad j = .95$

$b = \frac{I0,800,000}{56 \times (68)^2} = 42"$

$A = \frac{I0,800,000}{I5000 \times .95 \times 68} = II.2^{a}"$

Use twelve I-I/8" round rods.

Bond stress.

$u = \frac{224000}{(I2 \times 3.54)\ .95 \times 68} = 80\#^{a}"$

Shear.

$v = \frac{225000}{68 \times 25} = I33\#^{a}"$

I33 - 40 = 93# to be taken by U bars.

$\frac{d}{4} = \frac{68}{4} = I7"$ spacing.

$p = 93 \times 68 \times I7 = I07500\#$

$\frac{I07500}{I2000} = .90^{a}"$

Use 3/4" U bars, spacing I7".

DESIGN OF STAIRWAY.

Width of Stairs.

$72 = (15000 - 3000)\ 6 = 144" = 12'$

Two 24" Stairway Fire-escapes $= 4'$

Width of Stairs $= 8'$

Stairway is designed with two rectangular beams as strings supporting a 4" slab with risers and treads.

Distance between floors = 10'-0".

Use 15 risers at 8" and 14 treads at 12".

Design of 4" Slab.

Live Load	100# "
Weight of Slab	50
Total Load	150# "

$$M = \frac{150 \times 8^2 \times 12}{10} = 11530"\#$$

$$d^2 = \frac{11530}{600 \times 12} = 9.60 \qquad d = 3.1$$

A 4" slab is ample.

$$A = \frac{11530}{15000 \times .875 \times 3} = .30^{\square"}$$

Use 1/2" round rods, spacing 6", area $.392^{\square"}$

$$V = \frac{150 \times 8}{2} = 600^{\#}$$

$$U = \frac{600}{3.14 \times .875 \times 3} = 73\#^{\square"} \qquad \frac{600}{4 \times 12} = 12.5\#^{\square"} \qquad 40" \text{ allowable}$$

Design of Rectangular Beam.

Live Load = 100 x 4 =	400#
Concrete	300
Total Load	700#

M due to weight of beam $= \frac{300 \times \overline{14}^2 \times 12}{8} = 88200\#$

Total M = 164500 + 88200 = 252700"#

$\frac{M}{bd^2} = 98 \qquad d^2 = \frac{252700}{98 \times 10} = 225 \qquad d = 15$

Use a 10" x 15" beam.

$A = \frac{252700}{15000 \times .875 \times 13.5} = 1.43^{\square}"$

Use four 3/4" round bars, area $1.76^{\square}"$.

$V = \frac{700 \times 14}{2} = 4900\#$

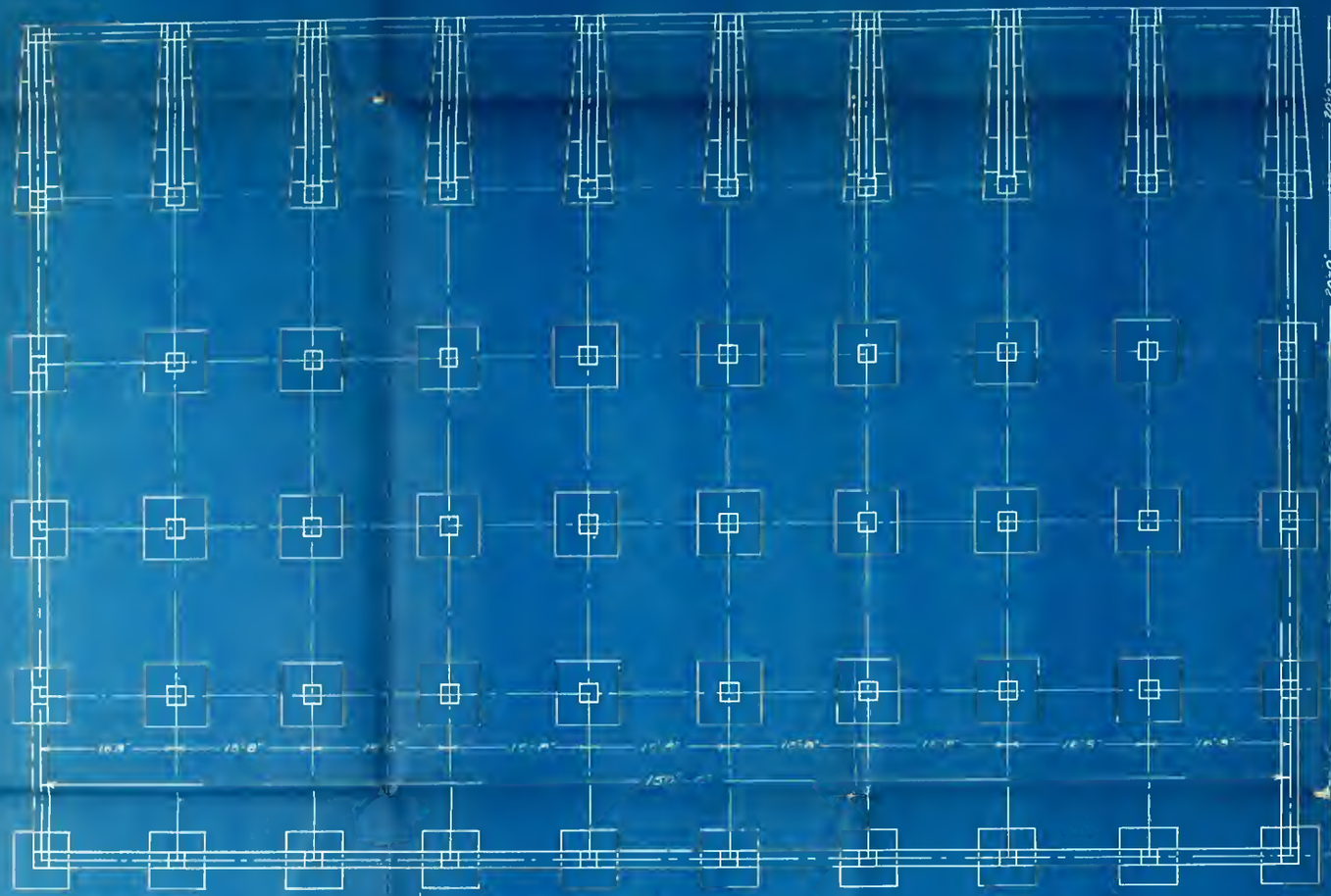
$U = \frac{4900}{4 \times 2.36 \times .875 \times 13.5} = 44\#/"$

$u = \frac{4900}{10 \times 15} = 33\#/"$

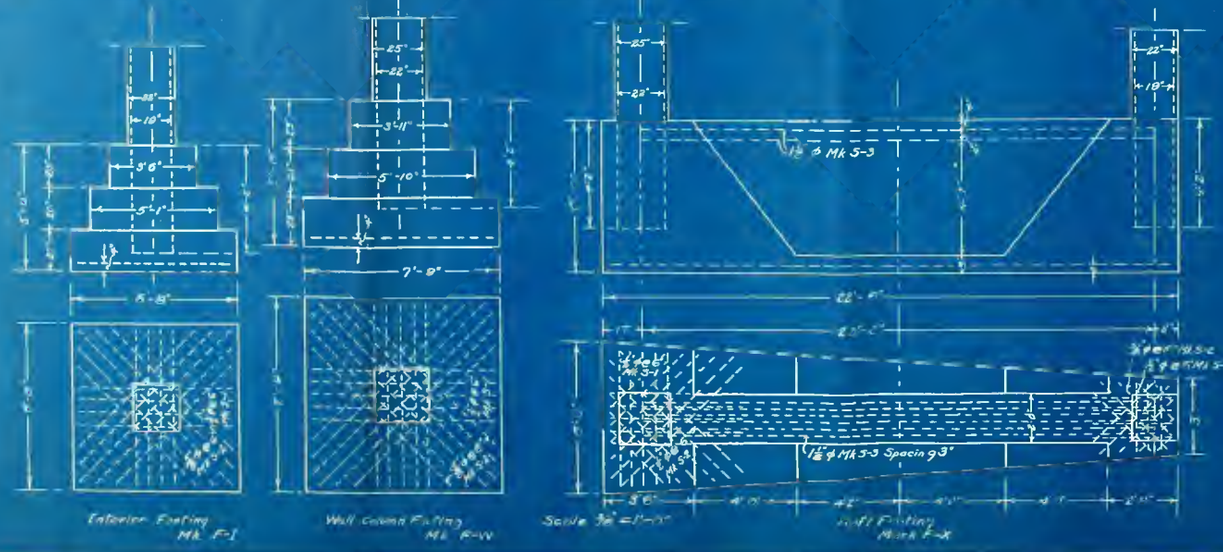
No shears bars are required.

PLANS.

PLAN OF FOOTINGS Scale 1/8"=1'-0"



Scale 1/8"=1'-0"



Schedule of Columns

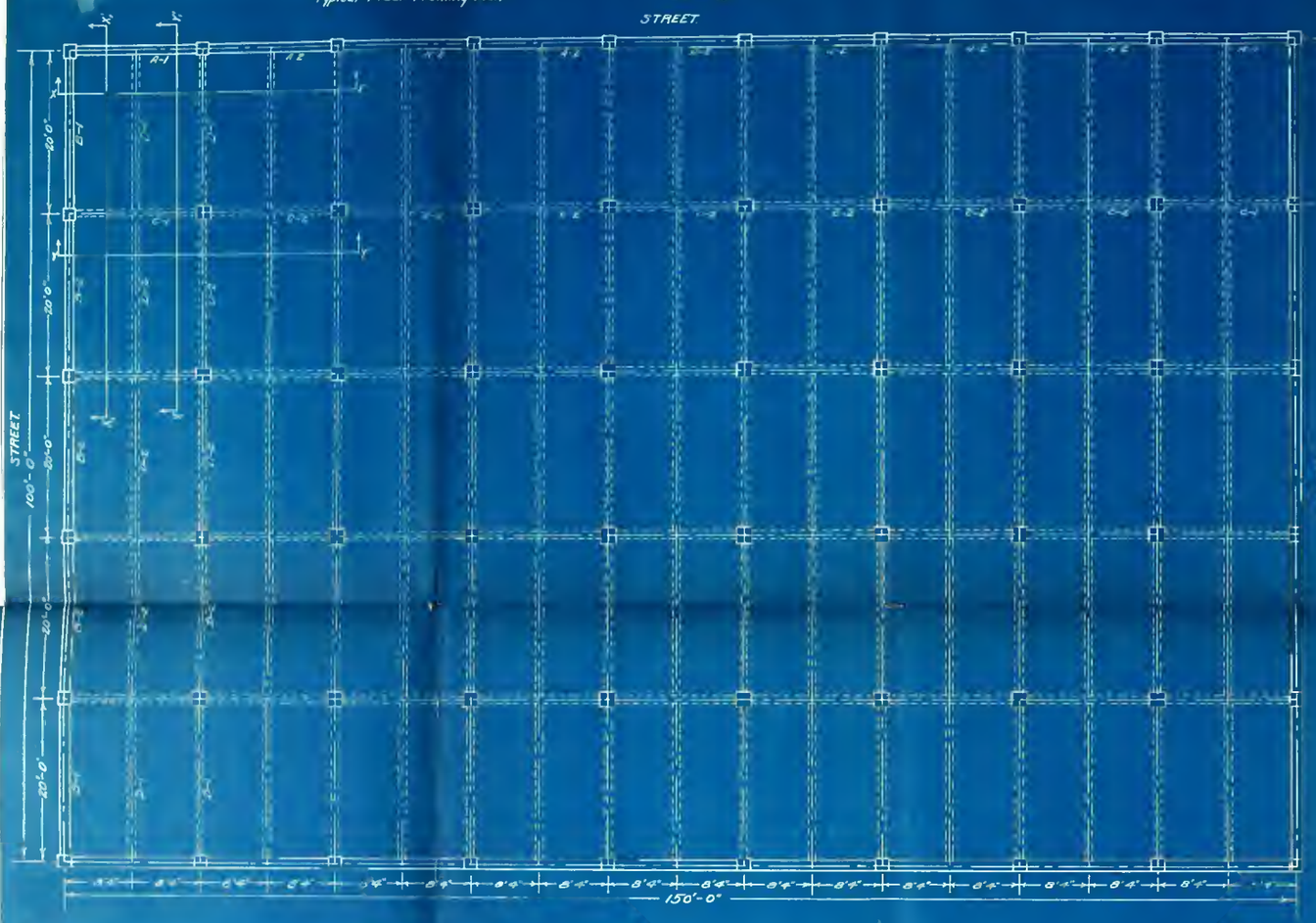
Mark	Number	Size	Steel	Remark
I-4	32	11"X11"X11'-0"	4-3/8" ϕ Length 13'-0"	All vertical reinforcement
I-3	32	16"X16"X11'-0"	8-3/4" ϕ " 15'-0"	in columns tied with
I-2	32	20"X20"X11'-0"	9-1" ϕ " 15'-0"	1/4" wire every 12"
I-1	32	22½"X22½"X11'-0"	8-1 3/8" ϕ " 15'-0"	
I-B	32	25"X25"X10'-0"	10-1 3/8" ϕ " 16'-0"	
W-4	28	18"X10"X11'-0"	4-1/2" ϕ " 13'-0"	
W-3	28	18"X12"X11'-0"	5 7/8" ϕ " 15'-0"	
W-2	28	18"X17"X11'-0"	8-3/4" ϕ " 15'-0"	
W-1	28	18"X22"X11'-0"	7-1 1/2" ϕ " 15'-0"	
W-B	28	22"X22"X10'-0"	9-1 3/4" ϕ " 16'-0"	

Schedule of Footings

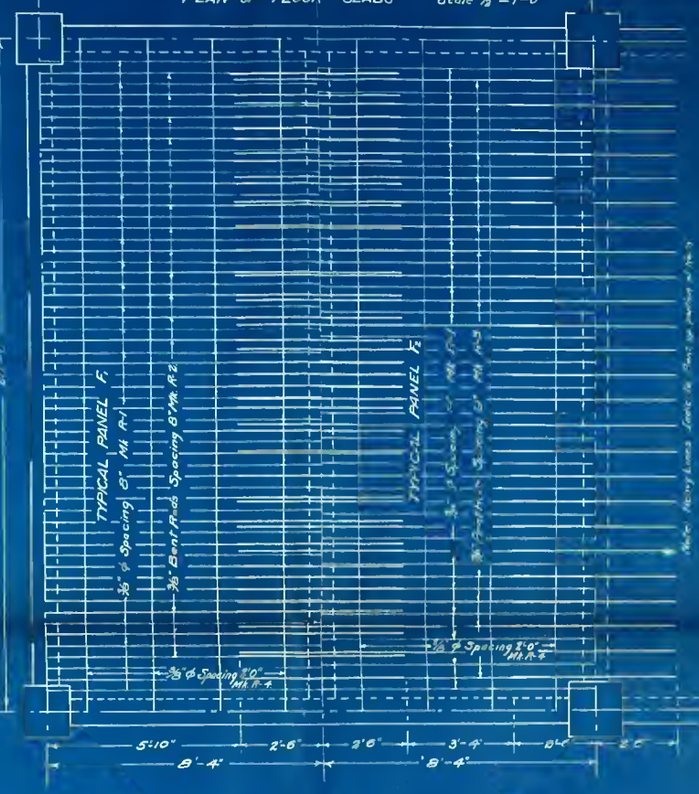
Mark	Number	Steel Mark S-1	Steel Mark S-2	Steel Mark S-3
F-I	24	8-1/2" ϕ Length 6'-0"	10-5/8" ϕ Length 8'-0"	
F-W	16	10-1/2" ϕ " 7'-0"	12-5/8" ϕ " 12'-0"	
F-X	10	8-1/2" ϕ " 3'-0"	10-5/8" ϕ " 14'-0"	12-1 1/2" ϕ Length 21'-0"
"	"	10-1/2" ϕ " 4'-0"	12-5/8" ϕ " 6'-0"	

ARMOUR INSTITUTE OF TECHNOLOGY
CIVIL ENGINEERING DEPARTMENT
PLANS OF A FOUR-STORY
REINFORCED CONCRETE BUILDING
Scale as indicated May 1913
Thesis Plate I
C.A. Leibrandt

Typical Floor Framing Plan Scale 1/8"=1'-0"

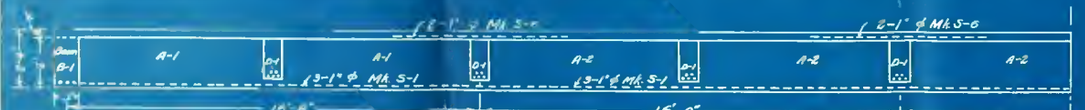


PLAN OF FLOOR SLABS Scale 1/8"=1'-0"



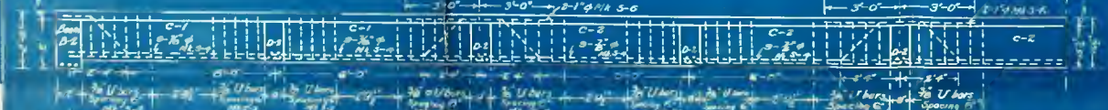
Schedule of Floor Slab Steel

Slab	No. per Floor	Steel
F	10	28 - 3/8" ϕ Mk-A-1 Length 8'-4"
"	"	28 3/8" Bent bars " A-2 " 10'-10"
"	"	6 - 3/8" ϕ " A-4 " 20'-0"
F1	80	26 - 3/8" ϕ " A-1 " 8'-4"
"	"	20 - 3/8" Bent bars " A-3 " 13'-4"
"	"	4 - 3/8" ϕ " A-1 " 20'-0"

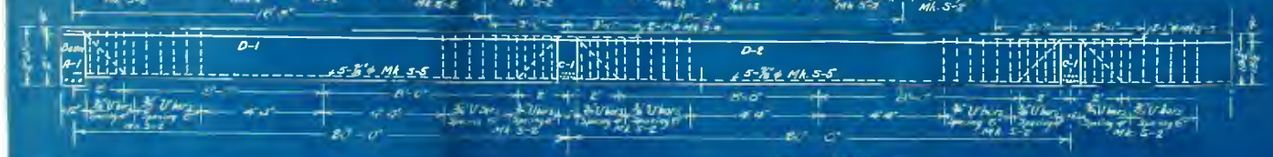


Section Thru X-X

Section Thru X-X



Section Thru Y-Y



Section Thru Y-Y

Scale 3/8"=1'-0"

SCHEDULE OF BEAMS

MARK	SIZE	LENGTH	No. per Floor	STEEL
A-1	12"X24"	16'-0"	4	3-1" ϕ Mk S-1 Length 16'-8"
				2-1" ϕ " S-6 " 5'-0"
B-1	12"X24"	20'-0"	4	3-1" ϕ " S-3 " 20'-0"
				2-1" ϕ " S-6 " 6'-0"
C-1	9"X18½"	16'-8"	8	9-⅞" ϕ " S-4 " 16'-8"
				2-1" ϕ " S-6 " 6'-0"
				22-⅜" U bars " S-2 6"X14"
D-1	9"X15½"	20'-0"	30	5-⅞" ϕ " S-5 Length 20'-0"
				2-1" ϕ " S-6 " 6'-0"
				22-⅜" U bars " S-2 6"X14"
A-2	12"X24"	16'-8"	14	3-1" ϕ Mk S-1 Length 16'-8"
				2-1" ϕ " S-6 " 6'-0"
B-2	12"X24"	20'-0"	6	3-1" ϕ " S-3 " 20'-0"
				2-1" ϕ " S-6 " 6'-0"
C-2	9"X15½"	16'-8"	28	9-⅞" ϕ " S-4 " 16'-8"
				2-1" ϕ " S-6 " 6'-0"
				22-⅜" U bars " S-2 6"X14"
D-2	9"X15½"	20'-0"	51	5-⅞" ϕ " S-5 Length 20'-0"
				2-1" ϕ " S-6 " 6'-0"
				22-⅜" U bars " S-2 6"X14"

ARMOUR INSTITUTE OF TECHNOLOGY
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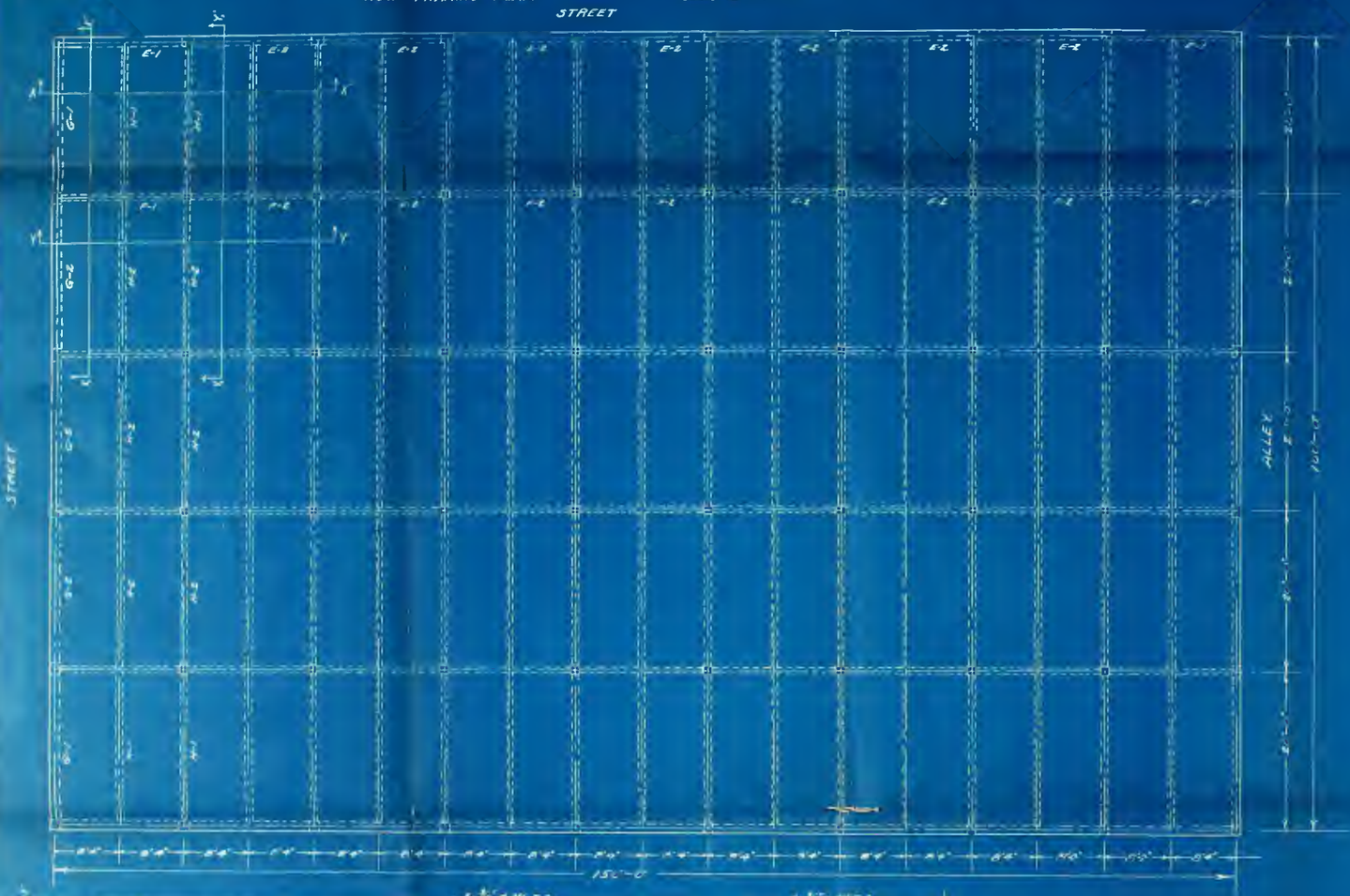
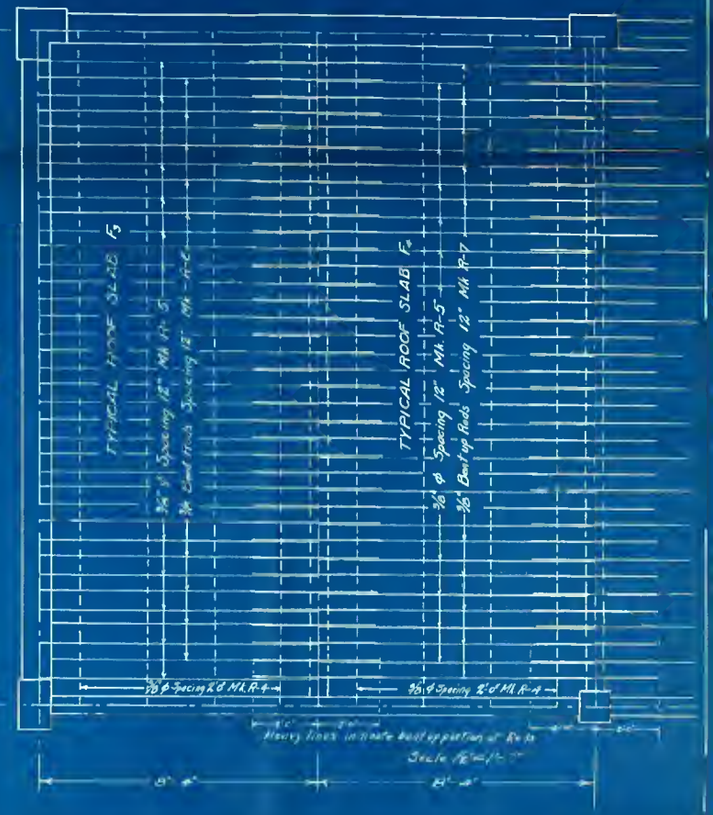
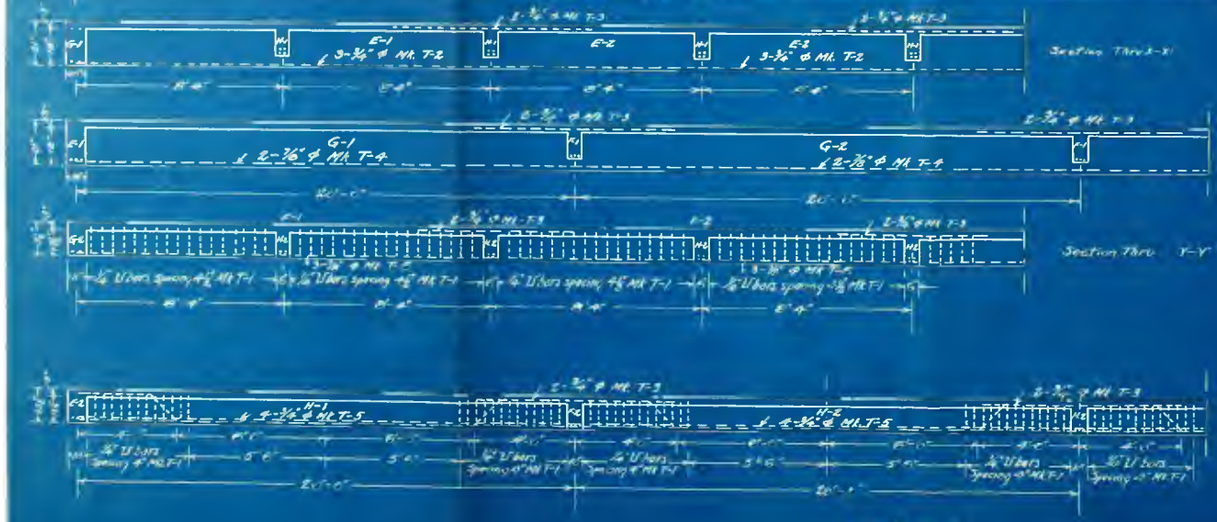
PLANS OF A FLOUR-STORY
REINFORCED CONCRETE BUILDING
Scale as indicated May 1913
Thesis Plate 2
C.A. Leiferman Jr.

ROOF FRAMING PLAN. Scale 1/8" = 1'-0"







SCHEDULE OF ROOF-SLAB STEEL

SLAB	No. Required	STEEL
F_3	10	19-3/8" ϕ Mk R-5 Length 8'-4"
		18-3/8" Bent Rods Mk R-6 " 10'-4"
		4-3/8" ϕ Mk R-4 " 20'-0"
F_4	80	10-3/8" ϕ Mk R-5 " 8'-4"
		19-3/8" Bent Rods Mk R-7 " 12'-4"
		4-3/8" ϕ Mk R-4 " 20'-0"

SCHEDULE OF ROOF BEAMS

MARK	SIZE	LENGTH	NO REQ	STEEL
E-1	10"X16"	16'-0"	18	3-3/4" ϕ Mk T-2 Length 16'-0"
				2-3/4" ϕ Mk T-3 " 8'-0"
G-1	10X18	20'-0"	10	2-7/8" ϕ Mk T-4 " 20'-0"
				2-3/4" ϕ " T-3 " 8'-0"
F-1	6"X12½"	16'-8"	36	3-7/8" ϕ " T-6 " 16'-8"
				2-7/8" ϕ " T-3 " 8'-0"
				34-½" U bars Mk T-1
H-1	6X12½	20'-0"	85	4-3/4" ϕ Mk T-5 " 20'-0"
				2-3/4" ϕ Mk T-3 " 8'-0"
				26-½" U bars Mk T-1

Illinois Institute of Technology
Civil Engineering Department
Plans of a Four-Story
Reinforced Concrete Building
Scale as indicated May 1913
Thesis Plate 3
O.R. Wilmarth